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October 30, 1963

INTERIM REPORT
JOINT MSFC-BELLCOMM CHECKOUT STUDY

I. Origin of Study

In reporting to OMSF the results of an ad hoc study of the MILA computer situation, Bellcomm, on the basis of its understanding of the job, reached certain conclusions about the launch vehicle checkout system. The most important of these were:

- (1) The RCA 110A was believed incapable of performing the LCC computer functions.
- (2) The LUT configuration was believed to have inadequate reliability because of inaccessibility during unattended phases of the countdown.
- (3) Further study was required.

The present joint MSFC-Bellcomm study of the launch vehicle checkout system was initiated to achieve the following broad objectives:

- (1) Reach a common definition of the checkout job to be done.
- (2) Develop reliability objectives for checkout systems.
- (3) Propose a checkout system to do the job and meet the reliability objectives.
- (4) Compare and evaluate the proposed system, relative to the system presently being developed.
- (5) Resolve the questions raised in the MILA computer study report.

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CHECKOUT STUDY INTERIM REPORT (NASA) 6 P

II. Checkout Job Definition

A basic difference between the Bellcomm and MSFC definitions of checkout was uncovered. Bellcomm uses the word in the way it is used in the Apollo System Specification. It considers checkout as an activity which starts at the factory and extends throughout the mission. MSFC thinks of the LCC checkout responsibility as ending when the launch vehicle status has been reported up to lift-off. In particular this definition excludes processing data and disseminating information for post-launch operational checkout uses.

This difference in definition led to an important misunderstanding. When MSFC and LOC said that CIF has no launch vehicle checkout responsibilities, Bellcomm understood the processing of launch vehicle checkout data for all purposes to be functions of the LCC computer.

As a matter of fact the storage, retrieval and processing of data derived during launch vehicle checkout, and the transmission of it to other operational locations, are assigned to the CIF as operational functions.

The conclusions reached below are based on the premise that this assignment will not be changed.

III. RCA 110A as the LCC Computer

The assignment to CIF of processing, storage, retrieval and transmission of data, originating in launch vehicle count-down checkout, results in a load much smaller than would otherwise fall on the LCC computer. Having assigned these tasks to CIF, duplication of the capability for doing them in LCC is not justified. The evaluation of the LCC computer capability made by Bellcomm therefore does not apply. The per cent loading of the LCC computer, in doing its presently assigned functions, has not yet been estimated either by MSFC or by Bellcomm.

IV. Reliability Requirements

High reliability is required from the checkout and count-down system for the purpose of insuring the capability of meeting launch windows with qualified space vehicles. This becomes an important problem because of:

- (1) The large number of systems that form the total Apollo system,

- (2) The limited number of launch windows, and
- (3) The premiums attached to performing on schedule.

Judgments have been made of the desired reliability of the checkout and countdown system. The desired reliability was derived from two different points of view. A failure to launch probability of 0.4 was assumed to be satisfactory and then a coarse apportionment of this failure probability was made among the various Apollo system elements. The other approach was to consider the reliability objectives of the launch vehicle system against those appropriate to a ground system. Both approaches yielded essentially the same reliability goals.

The reliability goals are:

- (1) All control electronics necessary to the performance of the LUT functions should have an 0.99 availability for seven continuous hours preceding launch. Without repair, this equates to 700 hours MTBF.
- (2) The control electronics in LCC should have an 0.995 availability for fifteen hours.

No defense of the accuracy of the specific numbers given above will be made. However, it is concluded that any reasonable set of requirements can be met only by using hardware redundancy and/or back up modes of operation.

V. LUT Configuration Reliability

The present LUT configuration was chosen for its capabilities and advantages during all phases of checkout, starting with S-IC stage checkout and extending through countdown. This configuration has been questioned on the basis of availability. It is agreed that the problem of availability of the LUT functions should be treated as a part of the overall ground-based control electronics reliability problem, which is under active study.

VI. General Checkout Systems Requirements

Consideration has been given to the characteristics desired in a checkout system to meet the long-range needs of the Saturn program. A first cut at a partial list of characteristics was made and the following list was agreed to:

- (1) No single component failure should cause system malfunction (including power failure).
- (2) Automatic hardware failure reporting.
 - (a) Minimize the probability of falsely reporting failures.
 - (b) Isolation of failure to a replaceable module.
- (3) On-line replacement of failed modules without degrading system operation.
- (4) System should have the ability to survive a power failure without erroneous operation and loss of system status information.
- (5) The system should operate without air conditioning.
- (6) A. C. coupled inputs and outputs.
- (7) Automatic, multilevel, program assignable, hardware priority interrupt.
- (8) Should meet all applicable NASA specifications.
- (9) Modular expandable system input-output equipment built to the same system requirements. This equipment should be capable of remote operation up to seven miles.

Additional computer and system characteristics were discussed but were not completely formulated. These are subjects for continuing study.

VII. Conclusions and Recommendations

The following conclusions and recommendations were drawn by MSFC and Bellcomm in their joint study.

The present Complex 39 checkout system is not capable of meeting the reliability goals as tentatively defined by the study. However, the study also showed that the present state-of-the-art in this type of hardware is such that these reliability goals cannot be met without some type of redundancy.

To provide this redundancy, short-range and long-range approaches are proposed. These proposals are:

(1) Short Range

- (a) Search for and develop within the Saturn I-B launch system, alternate modes of operation, particularly for the last phases of countdown, that allow the LCC computer to back up the computer on the LUT.
- (b) Utilize this system throughout the Saturn I-B program and in all areas of the Saturn V program including early firings from Complex 39.

(2) Long Range

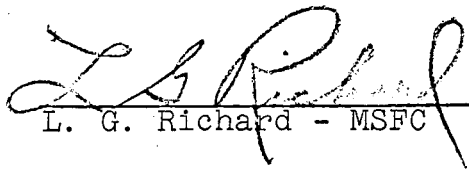
To make certain that the long-range needs of the Saturn program are fulfilled, a program should be started to produce a system that possesses all of the desired checkout system characteristics listed. This effort could conceivably go through the prototype stage. At that time it could be retrofitted as required or as deemed desirable from mission criteria viewpoints. Also such a program could lead to a standardized checkout system for Saturn without the compromises that are now necessary. However, this hardware cannot be expected to be available for the early portion of the lunar program. This is probably proper since experience in the early portion of the program should contribute a great deal to the determination of just what such a system should do and what it should consist of.


In considering the above proposals, no presently planned capability of on-LUT hardware should be sacrificed in the name of improving the overall system reliability until that overall system is completely defined. Improvements or deletions should be applied where they make substantial overall reliability gains that offset any loss in capability.

VIII. Continuing Study Work

The study work to produce a checkout system to meet the long-range needs of the Saturn program includes:

- (1) Derivation of operational requirements for the checkout system.
- (2) Derivation of a firmer set of availability requirements for the system.
- (3) Completion of the list of desired computer and system characteristics, and determination of the amounts and types of redundancy required.


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